Chapter 3

Selected Edible Insects and Their Products in Traditional Medicine, Food and Pharmaceutical Industries in Africa: Utilisation and Prospects

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Additional information is available at the end of the chapter

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Abstract

Edible insects are a widely exploited food source by many indigenous populations in most regions of the world. Edible insects have been used as food in sub-Saharan Africa, being a good source of protein and essential amino acid. Historically, they are important contributors to improving food and nutrition security, particularly for people who suffer from malnutrition due to protein deficiency. Africa is the continent with the highest number of records (19 countries), followed by the USA (5 countries) and Asia (5 countries). The species used for food and as feed include *Hodotermitidae, Kalotermitidae, Rhinotermitidae* and *Termitidae*. Insects, such as termites, are also eaten raw directly on emergence from the holes. Species used in traditional popular medicine include *Hodotermitidae* and *Termitidae*. They are used in the treatment of various diseases that affect humans such as influenza, asthma, bronchitis, whooping cough, sinusitis, tonsillitis and hoarseness.

Keywords: termites, *Isoptera*, micronutrients, therapeutics, utilisation, food security

1. Introduction

1.1. Overview on edible insects in sub-Saharan Africa

Insects have been consumed for generations in many regions of the world, a practice that has increased in popularity in recent years [1–6]. More than 2.5 billion people, mainly in Africa and Asia, commonly consume insects [7]. The use of termites was registered in 29 countries over three continents. Africa is the continent with the highest number of records (19 countries), followed by the USA (5 countries) and Asia (5 countries). Throughout the world, a large portion of the human population consumes insects as a regular part of

their diet. Insects' consumption, called Entomophagy, has played an important role in the history of human nutrition in Africa [8]. Currently, edible insects are gaining much attention for their high nutritional value and environmental advantages over meat production [9]. Their short life cycles, low space requirements, efficient nutrient conversion rates and lower greenhouse gas production render insects to be, in principle, an excellent alternative to meat [5]. It is postulated that termites contain high-quality nutrients including highly digestible proteins [10], as well as minerals, which are more bioavailable than minerals from plant foods [11]. Crickets in particular are believed to have higher quality animal protein than some conventional sources, such as fish, and are more affordable among poor communities [12]. Currently, attention is being drawn to this valuable traditional food resource, which if tapped or exploited could contribute to a more sustainable solution for malnutrition in sub-Saharan Africa. It is estimated that insects form part of the traditional diets of at least two billion people. Thousands of edible species have been identified [13–15]. More than 1900 species have reportedly been used as food [16, 17]. Insects deliver a host of ecological services that are fundamental to human survival. Termites are eusocial insects belonging to the family *Isoptera* that play a major role in the tropical ecosystem (**Figure 1**).

In general, insects are important in plant reproduction, waste bio-conversion and in biocontrol of harmful pest species leading to a variety of valuable food and non-food products used in applications such as maggot therapy [1]. They are used as collection items and ornaments and in movies, visual arts and literature. Globally, the most commonly consumed insects are beetles (*Coleoptera*, 31%), caterpillars (*Lepidoptera*, 18%) and bees, wasps and ants (*Hymenoptera*, 14%), grasshoppers, locusts and crickets (*Orthoptera*, 13%), cicadas, leafhoppers, planthoppers, scale insects and true bugs (*Hemiptera*, 10%), termites (*Isoptera*, 3%), dragonflies (*Odonata*, 3%), flies (Diptera, 2%) and other orders (5%) (**Figure 2**).

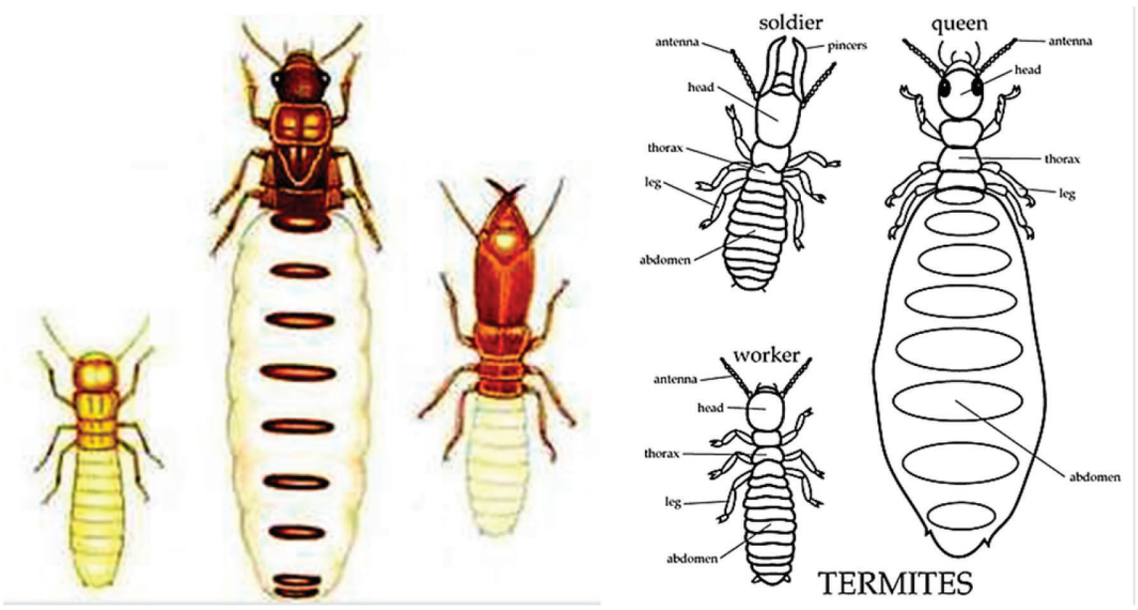

Figure 1. Structure of edible termites [18].

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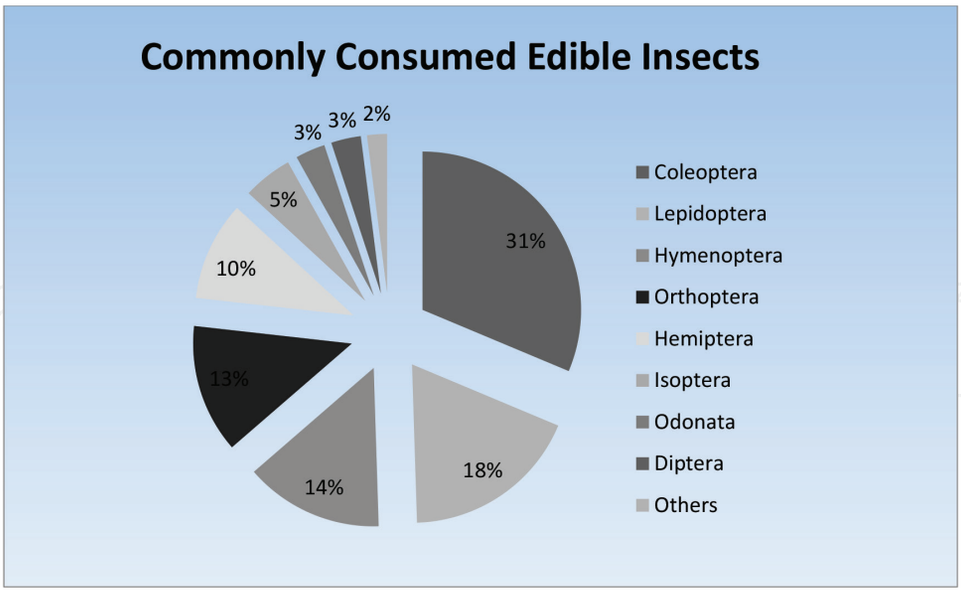

Figure 2. Commonly consumed edible insects globally [17].

The importance of insects as a food source for human is not surprising, since this is the group with the highest number of species in nature, thereby representing significant biomass [19]. Considered as important natural resources, insects are in many ways a basic component of the diets of humans and other animals [20] and have played an important role as a source of medicinal resources [21–24].

By 2050, the global population is estimated to be nine billion people and could possibly lead to a global food demand increase of up to 70% compared with our current food requirements [25]. Invariably, conventional sources of protein may not be sufficient for the global human population; hence, alternative sources such as insects will be required.

2. Edible insects in sub-Saharan Africa

2.1. Cultivation

The cultivation of edible insects in sub-Saharan Africa is not common as obtainable in developed economies. Although edible insects are popular in the continent, they are not cultivated and there appears to be no campaign strategies in place. This is attributable to a number of reasons ranging from cultural, behavioural to lack of understanding of nutritional benefits of insects in the continent. Rearing insects may also require minimal land or market introduction efforts, as insects already form part of some local food cultures. A recent study shows that house crickets (*Acheta domesticus*), common across Africa, are a highly valuable yet neglected source of proteins [12] contributing a viable solution to food security challenges.

Apparently, due to huge local and international demand for insect-based foods, insect farming initiatives seems to have taken off in Africa. Iwuoha [26] highlighted the following initiatives:

(i) The McGill Entomophagy Project—in September 2013, the Clinton Global Initiative seems to have awarded a significant prize to a team of student entrepreneurs from the McGill University in Montreal, Canada to fight hunger and nutrition deficiencies in developing regions of the world like Africa by improving diets with insect-based meals. This team, working with researchers and local insect farmers in Thailand, has assessed red palm weevil larva farming practices for possible translation to West Africa where palm weevil larva are eaten, but not farmed; (ii) Prof. Arnold van Huis (Insect Protein for Africa)—a researcher using insects as a sustainable source of protein for Africa—is on a drive to raise 1.5 million Euros in funding to carry out fundamental research of simple insect cultivation methods in Africa and (iii) AgriProtein—a South African business developing insect-based protein feed, extruded oil, and fertilisers since 2009 and has raised $11 million from strategic partners to commercialise and globalise its revolutionary concept.

2.2. Cultural and religious considerations

The consumption of insects as food is acceptable and practised by many cultures around the world [18]. Many ethnic groups in 130 countries utilise insects as essential elements of their diet, even in the United States there has been an increasing interest in insect-based food products in recent years [27]. Edible insects are a widely exploited food source by many indigenous populations in most regions of the world [18].

Entomophagy, the consumption of insects, is heavily influenced by cultural and religious practices in many regions of the world [28] and sometimes economic circumstance in some parts of Africa. Historical references to the use of insects for food are currently found in some religious literatures, for example, in the Bible, in Leviticus chapter 11, verse 22 and in Matthew chapter 3, verse 4 [29]. Despite these references, the topic of entomophagy has only very recently started to capture some attention worldwide. In the most developed economy, however, people still view entomophagy with disgust and associate eating insects with primitive behaviour. This attitude has resulted in the neglect of insects in agricultural research.

Edible termites form an important part of the food culture in the Lake Victoria region of East Africa [30, 31]. The study of Pambo et al. [32] shows that in Kenya attitudes, subjective norms and behavioural capabilities are considerations in designing food from edible insects (FEI) that are culturally appropriate. Their study proposed FEI as a viable option, given that insects are ubiquitous and that taste, availability/convenience, cost, nutrition, health benefits/risks and disgust factors are major determinants of consumption. Their study was conceptualised to identify potential differences in salient beliefs between participants from western region and those from eastern region, given that consumption of edible insects is popular in the western region. Although Pambo et al. [32] did not find potential differences in salient beliefs regarding insect consumption between two regions in Kenya, differences could exist between countries. Acceptance and popularity of FEI would depend much on campaign, nutrition literacy and other considerations. Kipkoech [12] observed that it took the presence of participants from different countries, continents and cultures, some of whom had tasted cricket before to demystify their consumption as food at a conference reception.

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2.3. Consumption

Insects, especially termites, have been used as food in sub-Saharan Africa, Asia, Australia and Latin America (**Table 1**). Edible insects consumption has been recently reported in Nigeria [33, 34] among which the termites had the highest mean frequency [33].

Some of the insects are eaten raw directly from the emergence hole [35, 36]. Although termite harvest begins with the onset of the rains and the swarming of the winged termites, villagers have shown that some termites could be induced to emerge even during the dry seasons,

Species	Country (ies)	Reference
Hodotermitidae		
Hodotermes mossambicus	Botswana	Gahukar [41]
Microhodotermes viator	South Africa	DeFoliart [18]
Kalotermitidae		
Kalotermes flavicollis	Brazil, Thailand	Jongema [17]
Rhinotermitidae		
Coptotermes formosanus	China	Jongema [17]
Reticulitermes flavipes	Thailand	Wilsanand [2]
Reticulitermes tibialis	Mexico	DeFoliart [18]
Termitidae		
Cubitermes atrox	Indonesia	Jongema [17]
Labiotermes labralis	Columbia	Jongema [17]
Macrotermes acrocephalus	China	Jongema [17]
Macrotermes falciger	Zimbabwe, South Africa	Wilsanand [2]
Macrotermes gabonensis	Congo	Jongema [17]
Macrotermes herus	Tanzania	McGrew and Roger [42]
Macrotermes lilljeborgi	Cameroon, Guinea	Deblauwe and Janssens [43]
Macrotermes michaelseni	Malawi	Sileshi et al. [44]
Macrotermes sub hyalinus	Angola, Zambia, Kenya	Lesnik [45]
Macrotermes vitrialatus	Zambia	Jongema [17]
Microcerotermes dubius	Malaysia	Jongema [17]
Nasutitermes ephratae	Venezuela	Jongema [17]
Odontotermes badius	South Africa, Zambia	Jongema [17]
Odontotermes capensis	South Africa	Jongema [17]
Odontotermes kibarensis	Uganda	Sileshi et al. [44]

Table 1. Termite species used as food or feed.

making them available throughout the year. Banjo et al. [37] were of the view that this has created attachment to the termite enterprise by locals to the extent that in some parts of the region, termite mounds are owned by individuals and sometimes form part of inheritance when one dies.

In many households, termites are a delicacy enjoyed by almost all ethnic communities in western Kenya. They are consumed as part of a meal or as a complete meal with tapioca, bread, roast corn or simply eaten as snack food. Some mothers grind the dried termites into flour and use it as a sprinkle in baby porridge [38]. Termites are also eaten raw directly from the emergence hole [35, 36]. Addition of termites to maize resulted in significant increase in β-carotene, niacin, vitamin B6, and B12 content, with significant reduction in thiamine, riboflavin and ascorbic acid content of enriched complementary foods.

The utilisation of insects as a sustainable and secure source of animal-based food for the human diet has continued to increase in popularity in recent years [39]. Many ethnic groups in approximately 130 countries utilise insects as essential elements of their diet. In recent years, in the United States, there has been an increasing interest in insect-based food products [27]. More than 2000 insect species and other small invertebrates are consumed as food by humans and animals alike [40] and used for either self-sufficiency or commercial food products in many parts of the world.

Insects link biodiversity conservation and human nutrition in a way that many other food sources do not. They often contain more protein, fat and carbohydrates than equal amounts of beef or fish, and a higher energy value than soy beans, maize, beef, fish, lentils or other beans [46].

3. Processing of edible insects

Insects are often consumed whole but can also be processed into granular or paste forms. In most western and eastern African countries, termites are collected during the rainy seasons as they emerge from holes on the ground. In western Kenya, this period is between April and October. They are prepared by blanching in boiling water, dried in the sun before frying in their own fat. Others dipped the crickets into hot water for 1 min and then sun-dried and ground them for use in making porridge, cookies and other sweet delicacies or deep-fry to get crispy crickets that would be eaten whole [12]. Surprisingly, the deep-fried crickets were everyone's favourite because of their delicious aroma and taste.

Several studies have shown that the product preparation affects the willingness to eat insects [47]. However, to date, consumer expectations and preferences towards different aspects of the product preparation have not been investigated, especially in sub-Saharan Africa. **Figure 3** shows the processing of mopane worms by frying.

Roasted termites moisture content was very low, while the crude protein, fat, carbohydrate and gross energy content were very high. Banjo et al. [37] stated that there was a significant reduction in moisture content of formulated complementary foods, the level of reduction increasing with increasing level of 10–20% inclusion of termites ($p<0.05$) with the values increasing with

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Figure 3. Mopane worm. http://int.search.myway.com/search/AJimage.jhtml [03 December 2016].

increasing level of inclusion of termites. They also reported significant increase in values of crude protein and fat, ash, total carbohydrates, mineral and gross energy of the formulated maize and sorghum complementary foods ($p<0.05$). However, they highlighted that some of the increases in value were lower than recommended by FAO/WHO.

4. Edible insects and bio-economy

Currently, attention is being drawn to this valuable traditional food resource, which if tapped or exploited is likely to be a more sustainable solution for nutrient deficiency. Considering the trajectory of the economy in sub-Saharan Africa, the gathering and farming of insects can offer employment and cash income, either at the household level or in larger, industrial-scale operations. In most parts of sub-Saharan Africa and Southeast Asia, the process of insect gathering, rearing and processing into street foods or for sale as chicken and fish feed is easily within reach of small-scale enterprises. With only a few exceptions, international trade in edible insects is insignificant, but border trade is significant. The trade that does exist in developed countries is often driven by demand from immigrant communities or because of the development of niche markets that sell exotic foods.

Some of the poorest people in Africa, living in urban and rural areas, can earn a living by the gathering, cultivation, processing and sale of edible insects. Such activities can improve diets, making available cash income by selling raw and processed insects as street foods or supply junior and high schools where school meals are served to pupils. Insects can be directly and easily collected from nature or farmed with minimal technical or capital expenditure considering the use of basic rearing and harvesting equipment.

5. Nutraceutical benefits

The nutraceutial benefit of insects is substantial varying as a result of the wide range of edible species. Within the same species, it has been shown that nutritional and medicinal values could differ based on the metamorphic stage of the insect, the habitat, and diet. They are a

readily available source of protein (**Figure 4**), lipids, carbohydrates, certain vitamins, and minerals such as calcium, iron, or zinc (**Table 2**). The protein content in insects is high, equivalent to that of fish and meat and is also said to be similar to the one found in a human body, making it easier to be utilised by the body as to compared to plant protein [13]. The energy content of insects is on average comparable to that of meat (on a fresh weight basis) except for pork because of its particularly high-fat content [48].

Dried termites have been reported to be a good source of dietary protein, fat and micronutrients [37, 50–52, 34]. Adepoju and Omotayo [34] reported termites to be low in anti-nutrients and suggested its possible inclusion in formulating adequate, nutrient-dense complementary foods with nutraceutical benefits. Addition of termites to maize resulted in significant increase in β-carotene, niacin, vitamin B6 and B12 content, with significant reduction ($p<0.05$) in thiamine, riboflavin and ascorbic acid content [37].

Termites constitute a food source of great nutritional value: high in protein and essential amino acids such as tryptophan, which is generally limiting in the food insects [53]. Termites are rich in minerals and other micronutrients. Essential fatty acids are well represented [54]. In general, heads of termites are better nutritionally featured than thorax and abdomens. Termites are undeniably rich sources of iron and their inclusion in the daily diet could improve iron status and help prevent anaemia in developing countries. Essential vitamins for stimulating metabolic processes and enhancing immune system functions are present in most edible insects such as termites. Booth [54] showed for a whole range of insects that thiamine ranged from 0.1 to 4 mg/100 g of dry matter. Insects contain significant amounts of fibre, as measured by crude fibre, acid detergent fibre and neutral detergent fibre. The most common form of fibre in insects is chitin, an insoluble fibre derived from the exoskeleton [17].

From a utilitarian perspective, termites are commonly used insects in entomotherapeutic practices and traditional popular medicine [20, 23, 55, 56] in the treatment of various diseases (**Table 3**) that affect humans, such as influenza, asthma, bronchitis, whooping cough, sinusitis, tonsillitis and hoarseness [57, 58]. They have historically been an important source of food that may contribute to improving human diet, particularly for people who suffer from malnutrition due to a deficit of protein [17], as they are considered a nonconventional food with great economic and social importance [3–6].

Figure 4. Some edible insects [49].

Insect or food item	Protein (g/kg)	Fat (g/kg)	Calories (kcal/kg)	Thiamine (mg/kg)	Riboflavin (mg/kg)
Black soldier fly	175	140	1994	7.7	16.2
House fly	197	19	918	13.3	77.2
House cricket	205	68	1402	0.4	34.1
Super worm	197	177	2423	0.6	7.5
Meal worm	187	134	2056	2.4	8.1
Giant mealworm	184	168	2252	1.2	16.1
Wax worm	141	249	2747	2.3	7.3
Silk worm	93	14	674	2.3	9.4
Beef	256	187	2776	0.5	1.8
Powder milk	165	268	4982	2.6	14.8

Source: Finke [50].

Table 2. Nutritional content of insects compared with other high-protein foods.

Species/family	Treated disease	Country	Reference
Hodotermitidae			
Hodotermes mossambicus	Child malnutrition	Zambia (Africa)	Cheng and Feng [59]
Termitidae			
Macrotermes bellicosus	Suture wounds	Somalia (Africa)	Wilsanand et al. [60]
Macrotermes nigeriensis	Wounds	Nigeria (Africa)	Alves [61]
Macrotermes exiguus	Asthma, flu etc.	Brazil	Alves [23]
Odontotermes feae	Ulcer, Rheumatics	India	Solavan et al. [55]
Pseudacanthotermes spinger	Antifungal properties	Brazil	Countinho [56]

Table 3. Termite species used in traditional medicine.

6. Prospects and challenges of edible insects industry

The induction of insect emergence during off seasons by villages [37] gives room for technological application in making insects available all through the year. This is an area that needs investigation as the world looks for alternative, environmentally friendly and cheaper sources of protein foods.

As earlier highlighted, edible termites are a good source of protein and the essential amino acid tryptophan. Many commercial food products are enriched with protein extracted or derived from legumes but insect protein is better in terms of nutritional properties and contains all the essential amino acids (**Table 2**). Adepoju and Omotayo [34] reported termites as being low in anti-nutrients and suggested their possible inclusion in formulating adequate, nutrient-dense complementary foods. Moreover, some insects (**Table 4**) are richer in protein

Insect order	Stage	Range (% protein)
Coleoptera	Adult and larvae	23–66
Lepidoptera	Pupae and larvae	14–68
Hemiptera	Adult and larvae	42–74
Homoptera	Adult, larvae and egg	45–57
Hymenoptera	Adult, pupae, larvae and egg	13–177
Odonata	Adult and naiad	46–65
Orthoptera	Adult and nymph	23–65

Source: Xiaoming et al. [63].

Table 4. Crude protein content of some insect order.

than beans (23.5% of protein), lentils (26.7%) or soybean (41.1%) [62]. At present, extraction processes for specific food ingredients are too costly and will need to be further developed to render insects profitable and applicable for industrial use in the food and feed sectors.

In the continent, the role of the media, peers and health officials in a FEI intervention need to be given consideration [32]. A theory-based intervention targeting FEI consumption and nutrition literacy, and ultimately increase the intake of FEI among the target population was proposed by Pambo et al. [32].

As stated by Pambo et al. [32], population growth, urbanisation and climate change are among the factors that have created uncertainties and pressures on current global food and economic systems. Insects as food and consumption of foods from edible insects are being promoted as one potential solution to the declining access to protein foods. It has been said by various authors that with the increasing global population, one of the strategies to improve food and nutrition security is to diversify diets using available food sources [25, 64, 65, 46, 3, 5, 12]. However, one of the challenges facing consumption [66] of edible insects is the limited information regarding consumer-psychographic characteristics including attitudes, values, interests and beliefs.

7. Conclusion and recommendation

Insects abundantly thrive in Africa, given the prevailing tropical climate. As the price of beef, chicken and fish continue to rise across the world, there is a huge opportunity for insects to meet the animal protein needs of human beings and livestock. It is now the view that edible insects have more iron than sirloin beef. One area of challenge in edible insect promotion, consumption and commercialisation is the consumer-psychographic characteristics. Edible insects are a highly nutritious and healthy food source with high fat, protein, vitamin, fibre and mineral content. The consumption of edible insects should be emphasised as this could be one of the sustainable strategies towards the alleviation of poverty, hunger and malnutrition in sub-Saharan Africa.

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References

[1] Van-Huis H. Insects as food in sub-Saharan Africa. Insect Science and Its Application. 2003;**23**:163-185

[2] Wilsanand V. Utilization of termite, *Odontotermes formosanus* by tribes of South India. Journal of Medicine and Food. 2005;**4**:121-125

[3] Johnson DV. The contribution of edible forest insects to human nutrition and to forest management: Current status and future potential. In: Durst PB, Johnson DV, Leslie RN, Shono K, editors. Forest Insects as Food: Humans Bite Back. Thailand: Food and Agriculture Organization of the United Nations; 2010. pp. 5-22

[4] Niaba KV, Atchibri LO, Gbassi KG, Beugre AG, Adou M, Anon AB. Consumption survey of edible winged termites in Cote d'Ivoire. International Journal of Agriculture and Food Science. 2012;**2**:149-155

[5] Van Huis A; Vantomme P. Conference report: Insects to feed the world. Food Chain. 2014;**4**:184-193

[6] Shockly M, Dossey AT. Insects for human consumption. In: Morales-Ramos J, Rojas G, Shapiro-Ilan DI, editors. Mass Production of Beneficial Organisms. London: Elsevier; 2014. pp. 617-652

[7] FAO (Food and Agriculture Organization of the United Nations). Biodiversity and sustainable diets: United against hunger. Report presented at World Food Day/World Feed Week; 2-5 November 2010; Rome

[8] Srivastava SK, Babu N, Pandey H. Traditional insect bioprospecting: As human food and medicine. Indian Journal of Traditional Knowledge. 2009;**8**:485-494

[9] Van-Huis H, Van Gurp H, Dicke M. Potential of insects as food and feed in assuring food security. Annual Review on Entomology. 2013;**58**:563-583

[10] Kinyuru JN, Kenji GM, Muhoho SN. Nutritional potential of longhorn grasshopper (*Ruspolia differens*) consumed in Siaya District, Kenya. Journal of Agriculture, Science and Technology. 2010;**12(1)**:1-24

[11] Omotoso OT. Nutritional quality, functional properties and anti-nutrients of the larva of *Cirinaforda* (Westwood) (Lepidoptera: Satuniidae). Journal of Zhejang University. 2006;**7(5)**:51-55

[12] Kipkoech C. Neglected insects as a remedy for food insecurity: The case of crickets. RUFORUM Weekly. 2017;**1**: 3. A weekly digest of News, Events and Opportunities. RUFORUM Communication communications=ruforum.org@mail75.suw11.mcdlv.net

[13] Bukkens SGF. The nutritional value of edible insects. Ecology of Food and Nutrition. 1997;**36**:287-319

[14] Bukkens SGF, Paoletti, MG. Insects in the human diet: Nutritional aspects. In: Paoletti MG, editor. Ecological Implications of Mini Livestock: Role of Rodents, Frogs, Snails, and Insects for Sustainable Development. New Hampshire: Science Publishers; 2005; pp. 545-577

[15] DeFoliart GR. Insects as food: Why the western attitude is important. Annual Review of Entomolology. 1999;**44**:21-50

[16] Ramos-Elorduy J. Energy supplied by edible insects from Mexico and their nutritional and ecological importance. Ecology of Food and Nutrition. 2009;**47**:280-297

[17] Jongema Y. List of edible insect species of the world. 2014; http://www.wageningenur.nl/en/ExpertiseServices/Chairgroups/PlantSciences/Laboratory-of-Entomology/Edible-insects/Worldwidespecies-list.htm. [Accessed from 05 November 2014]

[18] DeFoliart GR. The human use of insects as food resource: A bibliographic account in progress. 2002; http://www.food-insects.com/book7_31/The%20Human%20Use%20of%20Insects%20as%20a%20Food%20Resource.htm]

[19] Meyer-Rochow VB, Chakravorty J. Notes on entomophagy and entomotherapy generally and information on the situation in India in particular. Journal of Ethnobiology and Ethnomedicine. 2013;**48**:105-112

[20] Raubenheimer D, Rothman J. Nutritional ecology of entomophagy in humans and other primates. Annual Review of Entomology. 2012;**58**:141-160

[21] Costa-Neto EM. Entomotherapy, or the medicinal use of insects. Journal of Ethnobiology. 2005;**25**:93-114

[22] Dossey AT. Why insects should be in your diet. Scientist. 2010;**27**:22-23

[23] Alves RRN. Fauna used in popular medicine in Northeast Brazil. Journal of Ethnobiology and Ethnomedicine. 2011;**5**:1-30

[24] Alves RRN, Albuquerque UP. Animals as a source of drugs: Bioprospecting and biodiversity conservation. In: Alves RRN, Rosa IL, editors. Animals in Traditional Folk Medicine: Implications for Conservation. Heidelberg: Springer; 2013. pp. 67-89

[25] FAO (Food and Agriculture Organization of the United Nations). How to Feed the World in 2050. 2009. http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf [Accessed 10 March 2015]

[26] Iwuoha J-P. The Top 4 Most Widely Eaten Insects in Africa, and Why Insect Farming Has Become a Big Business Opportunity. 2015. http://www.smallstarter.com/browse-ideas/top-4-most-eaten-insects-in-africa-and-why-insect-farming-is-a-huge-business-opportunity/Agribusiness and Food, Business ideas. Tweets by @smallstarters. [Accessed 22 January 2017]

[27] Dossey A, Morales-Ramos J, Guadalupe R. Insects as Sustainable Food Ingredients: Production, Processing and Food Applications. 1st ed., 2016. Academic Press, Cambridge, MA, USA.

[28] Cerritos R. Insects as food: An ecological, social and economical approach. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources. 2009;**4(27)**:1-10

[29] James K. The Holy Bible. Authorised King James Version (KJV). World Bible Publishers, Inc.: USA; 1986

[30] DeFoliart GR. Insects as human food: Some nutritional and economic aspect. Crop Protection. 1999;**11**(5):395-599

[31] Ayieko MA. Nutritional value of selected species of reproductive *Isoptera* and Ephemeroptera within the ASAL of Lake Victoria basin. Journal of Discovery and Innovation. 2007;**19(2**):126-130

[32] Pambo KO, Mbeche RM, Okello JJ, Kinyuru JN, Mose GN. Consumers' salient beliefs regarding foods from edible insects in Kenya: A qualitative study using concepts from the theory of planned behaviour. African Journal of Food, Agriculture, Nutrition and Development. 2016;**16(4):**11366-11385

[33] Cloutier J, editor. Edible Insects in Africa: An Introduction to Finding, Using and Eating Insects. 1st ed. Wageningen Digigrafi, Veenendaal, Netherland: Agromisa Foundation and CTA; 2015. ISBN Agromisa: 978-90-8573-146-7, ISBN CTA: 978-92-9081-577-8

[34] Adepoju OT, Omotayo OA. Nutrient composition and potential contribution of winged termite (*Marcrotermes bellicosus* Smeathman) to micronutrient intake of consumers in Nigeria. British Journal of Applied Science and Technology. 2014;**4(7**):1149-1158

[35] Christensen DL, Orech FO, Mungai MN, Larsen T, Friss H, Aagaard-Hansen J. *Entomophagy* among the Luo of Kenya: A potential mineral source? International Journal of Food Science and Nutrition. 2006;**57:**198-203

[36] Ayieko MA., Ndong'a FO, Tamale A. Climate change and the abundance of edible insects in the Lake Victoria Region. Journal of Cell and Animal Biology. 2010;**7**:112-118

[37] Banjo AD, Lawal OA, Songonuga EA. The nutritional value of fourteen species of edible insects in southwestern Nigeria. African Journal of Biotechnology. 2006;**5**:298-301

[38] Bergeron D, Rodney JB, Franklin LR, Irv K, John O, Alfred AB. The nutrient composition of an insect flour sample from Lake Victoria, *Uganda*. Journal of Food Composition and Analysis. 1988;**11**:371-377

[39] Dossey AT. Insects and their chemical weaponry: New potential for drug discovery. 2013;**27**:1737-1757

[40] de Figueirêdo RECR, Vasconcellos A, Policarpo IS, Alves RRN. Edible and medicinal termites: A global overview. Journal of Ethnobiology and Ethnomedicine. 2015;**11**:29. DOI: 10.1186/s13002-015-0016-4

[41] Gahukar RT. Food security: The challenges of climate change and bioenergy. Current Science. 2009;**96**:26-28

[42] McGrew WC, Roger E. Brief report: Chimpanzees, tools, and termites: New record from Gabon. American Journal of Primatology. 1985;**5**:171-174

[43] Deblauwe I, Janssens G. New insights in insect prey choice by chimpanzees and gorillas in southeast Cameroon: The role of nutritional value. American Journal of Physics and Anthropology. 2008;**135**:42-55

[44] Sileshi GW, Nyeko P, Nkunika POY, Sekematte BM, Akinnifesi FK, Ajayi OC. Integrating ethno-ecological and scientific knowledge of termites for sustainable termite management and human welfare in Africa. Ecology. 2009;**14**:1-21

[45] Lesnik JL. Termites in the hominin diet: A meta-analysis of termite genera, species and castes as a dietary supplement for South African robust australopithecines. Journal of Human Evolution. 2014;**71**:1-11

[46] FAO. Edible Insects: Future Prospects for Food and Feed Security. Forestry Paper No. 171. Rome: Food and Agriculture Organization of the United Nations; 2013

[47] Tan JC, Jakob WB, Rossow G. Increase in tropical rainfall driven by changes in frequency of organized deep convention. Nature. 2015;**519**:451-454

[48] Sirimungkararat S, Saksirirat W, Nopparat T, Natongkham A. Edible products from eri and mulberry silkworms in Thailand. In: Durst PB, Johnson DV Leslie RN, Shono K, editors. Forest Insects as Food: Humans Bite Back. Bangkok, Thailand: FAO; 2010. pp. 189-200

[49] NEWS24. Top 5 insects you should be eating. 2017. http://www.news24.com/Green/News/Top-5-insects-you-should-be-eating-20140708

[50] Finke MD. Complete nutrient content of four species of feeder insects. Zoology Biology. 2012, 32(1): 27-36.

[51] Ekpo KE, Onigbinde AO, Asia IO. Pharmaceutical potentials of the oils of some popular insects consumed in Southern Nigeria. African Journal of Pharmacy and Pharmacology. 2009;**3**:51-57

[52] Adeyeye EI. Fatty acid composition of *Zonocerus variegatus*, *Macrotermes bellicosu*s and *Anacardium occidentale* kernel. International Journal of Pharmacology and Bio-Sciences. 2011;**2(1)**:B135-B144

[53] De Foliart GR. Overview of role of edible insects in preserving biodiversity. In: Paoletti MG, editor. Ecological Implications of Minilivestock. USA: Enfield NH Science Pub; 2005; pp. 123-140

[54] Booth RG. A review of the species resembling *Chilocorus nigrita* (*Coleoptera: coccinellidae*): Potential agents for biological control. Bulletin of Entomological Research. 1998;**88**:361-367.

[55] Solavan A, Paulmurugan R, Wilsanand V. Effect of the subterranean termite used in the South Indian folk medicine. Indian Journal of Traditional Knowledge. 2006;**5**:376-379.

[56] Coutinho HDM, Vasconcellos A, Lima MA, Almeida-Filho GG, Alves RRN. Termite usage associated with antibiotic therapy: Enhancement of aminoglycoside antibiotic activity by natural products of *Nasutitermes corniger* (Motschulsky 1855). BMC Complement Alternative Medicine. 2009;**9**(35):1-4

[57] Alves RRN, Alves HN. The faunal drugstore: Animal-based remedies used in traditional medicines in Latin America. Journal of Ethnobiology and Ethnomedicine. 2010;**7:**1-43

[58] Alves RR, Dias TL. Usos de invertebrados na medicina popular no Brasil esuas implicações para conservação. Tropical Conservation Science. 2010;**5**:159-174

[59] Cheng X, Feng Y. The Edible Insects of Chin. Beijing: Science and Technology Publishing House; 1999; pp. 15-20

[60] Wilsanand V, Preema V, Rajitha P. Therapeutics of insects and insects' products in South Indian traditional medicine. Indian Journal of Pharmacology. 2007;**6**:563-568

[61] Alves RRN. The faunal drugstore: Animal-based remedies used in traditional medicines in Latin America. Journal of Ethnobiology and Ethnomedicine. 2010;**7**:1-43

[62] Ramos-Elorduy J, Moreno JMP, Camacho VHM. Could grasshoppers be a nutritive meal. Food and Nutrition Sciences. 2012;**3:**164-175

[63] Xiaoming C, Ying F, Hong Z, Zhiyong C. Review of the nutritive value of edible insects. In: Durst PB, Johnson DV, Leslie RL, Shono K, editors. Forest Insects as Food: Humans Bite Back. Proceedings of a Workshop on Asia-Pacific Resources and Their Potential for Development; Bangkok: FAO Regional Office for Asia and the Pacific; 2010.

[64] FAO. Forest insects as food: Humans bite back. In: Durst PD, Johnson, DV, Leslie RN, Shona K, editors. In: Proceedings of a Workshop on Asia-Pacific Resources and their Potential for Development; 19-21 February 2008; Bangkok, Thailand: Chiang Mai University

[65] Münke-Svendsen C, Ekesi S, Ayieko M, Kinyuru J, Halloran A, Makkar H and Roos N. Insects as food and feed in Kenya: Past, current and future perspectives. Greeinsect Technical Brief No. 1, Copenhagen, Denmark; 2016.

[66] Verbeke W. Profiling consumers who are ready to adopt Insects as a meat substitute in a western society. Food Quality and Preference. 2015;**39**:147-155.

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